Variability in Evolution and Course of Gunshot Injuries to the Neck and Impact on Management

A Case Report

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Summary

This study reports the differences in evolution and course of multiple pseudoaneurysms (PAs) and an axillary arteriovenous fistula (AVF) after penetrating vascular trauma due to shotgun injury to the head and neck.

We describe the unusual case of a young man who, following penetrating shotgun injuries to the head and neck, developed multiple PAs of the common carotid, vertebral and superficial temporal arteries as well as an axillary AVF. Serial angiographic follow-up studies documented differences in time of occurrence, evolution and course of these lesions. This allowed for tailored management using endovascular (AVF, superficial temporal artery PAs) and conservative (carotid and vertebral PAs) treatment. No complication occurred and complete cure of all lesions was achieved and documented after seven months.

Time of occurrence, evolution and regression of penetrating vascular injuries can differ significantly even in the same patient. Close angiographic follow-up helps not only detect a lesion with delayed occurrence, but also provides a practical basis for decision-making for optimal therapeutic management.

Introduction

Pseudoaneurysms (PAs) and arteriovenous fistulas (AVFs) are frequent complications of gunshot injuries (GSIs) and are the most common undiagnosed vascular injuries of the extracranial vasculature [1]. They may remain clinically silent and spontaneously resolve with conservative management or may result in immediate, sometimes severe symptoms, requiring early surgical or endovascular repair [2,3]. Delayed occurrence and diagnosis can result in serious complications, such as bleeding and ischemic stroke [4,5]. Data on the natural history of PAs in the extracranial vasculature are limited and no consensus exists on their optimal management [6]. While some studies advocate endovascular or surgical treatment to prevent expansion, hemorrhage, or embolic ischemia [5,7], others suggest conservative management [8].

We describe a patient who, following a shotgun injury to the head and neck, developed an axillary AVF and multiple extracranial PAs in different territories that differed markedly in their time of occurrence and evolution over a course of seven months. Serial angiograms were used for diagnosis, follow-up and guidance of therapy using conservative management and endovascular treatment (EVT).

Case Report

A 20-year-old man with multiple shotgun pellet wounds to left face, skull, neck, and shoulder presented to the emergency center with swelling of the left face and lower neck area. Computed tomographic angiography (CTA) revealed a large hematoma in the neck

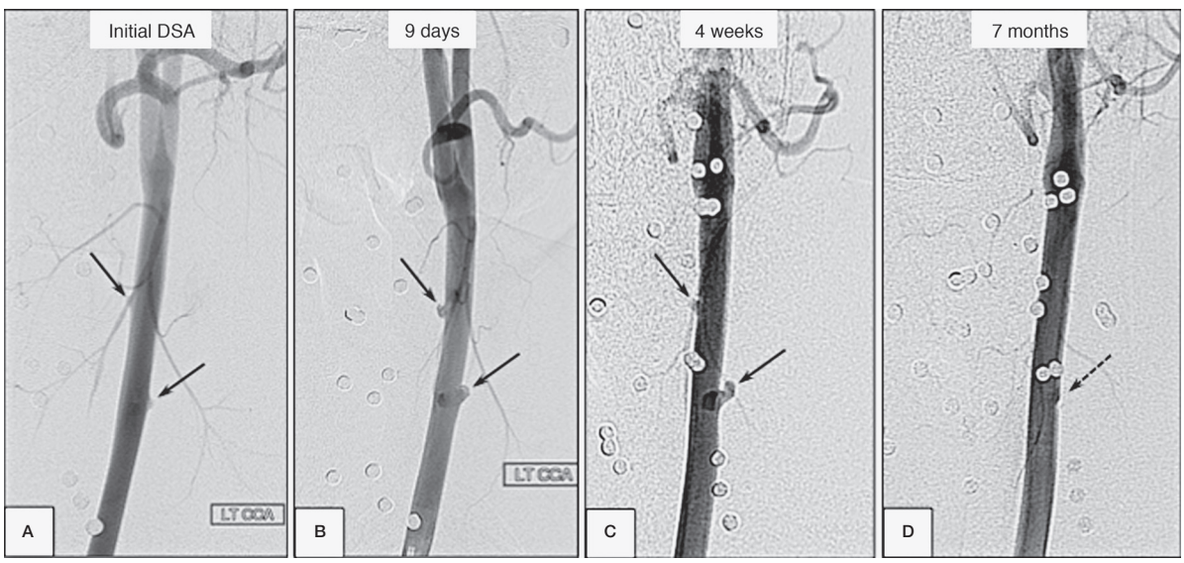

Figure 1 Course of common carotid pseudoaneurysms. A-D) Left CCA injections at admission, 9 days, 4 weeks and 7 months: the initial angiogram shows minimal outpouchings (arrows), not identifiable on CTA; 9 day and 4 week follow-ups reveal growing PA while after 7 months complete healing is documented.

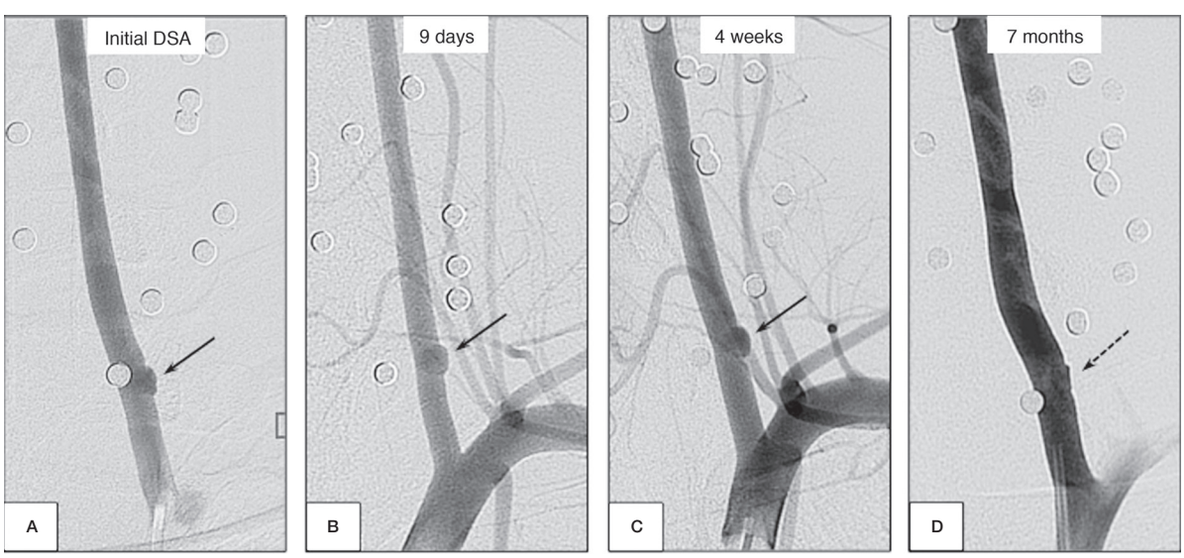

Figure 2 Course of left vertebral artery pseudoaneurysm. A-D) Left subclavian and vertebral artery injections at admission, 9 days, 4 weeks and 7 months. The small PA at the proximal vertebral artery (arrows) initially slightly increases and then decreases in size with only a subtle irregularity during the last follow-up examination.

soft tissues causing tracheal deviation, without a clear evidence of arterial injury.

Digital subtraction angiography (DSA) did not show active extravasation and the hematoma was thought to be venous in origin. However, two small wide-neck PAs (3 × 1.5 mm and 2.5 × 1.3 mm) of the left common carotid artery (CCA) and a single PA (3.3 × 1.3 mm) of the left vertebral artery (VA) were identified (Figures 1A and 2A). In addition, the left superficial temporal artery (STA) showed abrupt occlusion over the temple (Figure 3A). Antiplatelet therapy with daily dose of 81 mg aspirin was initiated. A follow-up nine days later documented a new CCA-PA and growth of the larger CCA-PA (Figure 1B). The left VA-PA had also grown minimally (Figure 2B). In addition, three new left STA-PAs (Figure 3B) at the ini-

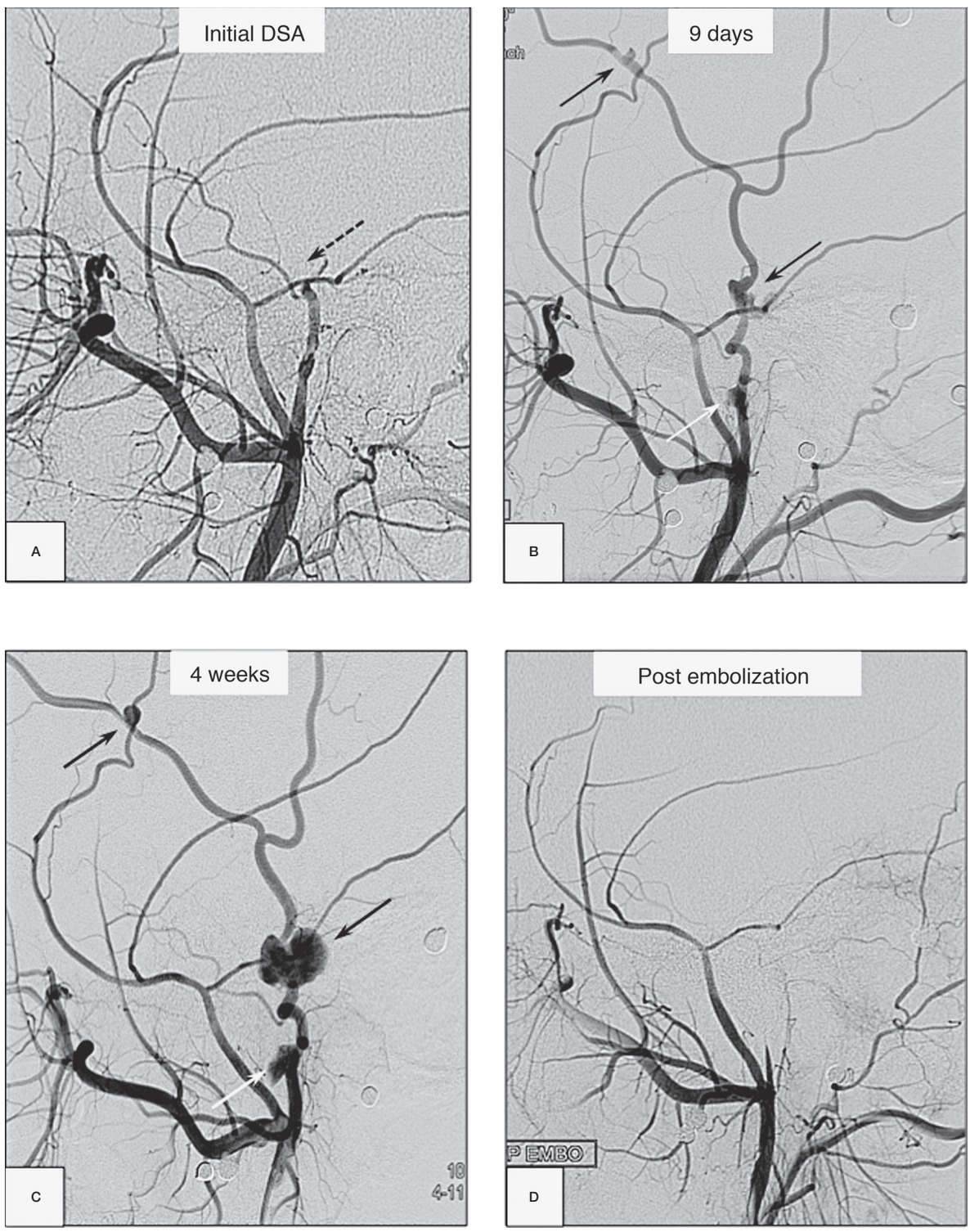

Figure 3 Developing superficial temporal artery pseudoaneurysms. A-D) Left ECA injection lateral views at admission, 9 days, 4 weeks pre and post embolization. Initial angiogram shows abrupt occlusion of the STA, but no extravasation; 9 days later, the STA is fully recanalized and shows 3 newly developed PAs (arrows). C) Significant increase in size after 4 weeks (arrows) and complete occlusion after embolization with glue (NBCA).

tially occluded segment were identified. Subclavian artery injections revealed previously not observed early venous return arising from a newly developed axillary AVF between branches of the left humeral circumflex artery and axillary vein (Figure 3C,D). EVT was not considered at that time, as both lesions were neither symptomatic nor flow-limiting. However, given the progression in size and number of the CCA lesions, aspirin dose was increased to 325 mg daily. Anticoagulation therapy with warfarin was also initiated for treatment of pulmonary thromboembolism attributed to prolonged patient immobilization.

The patient was scheduled for a four-week follow-up angiogram, but presented to the emergency center after 20 days with increasing left upper extremity edema and pain. DSA now showed an increase in size of the left axillary AVF and of the largest CCA-PA, while the remaining two CCA and the VA-PAs remained unchanged (Figure 2C). One STA-PA had significantly increased in size from 5 mm to 13 mm (Figure 3C).

The following day, under general anesthesia and full heparinization, using a coaxial technique, coil embolization of the fistula site (Tornado, Cook Medical, Bloomington, IN, USA) (Figure 3E) was performed and resulted in complete occlusion. During the same session, the STA-PAs were occluded with injection of 1cc glue (50% n-butyl-2-cyanoacrylate (NBCA) (Figure 2D). The following day, the patient reported decreased arm swelling and reduced pain. Aspirin was discontinued six weeks after discharge.

The patient was then temporarily lost to follow-up, but DSA seven months later confirmed stable occlusions of the STA-PAs and the left axillary AVF (Figure 4F). The PAs of the left CCA and VA had also nearly healed (Figure 1D,H). The patient complained of some residual minor pain and occasional paresthesias in the left shoulder, mainly attributed to remaining multiple subcutaneous pellets.

Discussion

Approximately 25% of penetrating trauma to the neck result in vascular injuries [9]. While rapid diagnosis and emergent therapy of vessel extravasation, occlusion, and dissection often command the primary focus [10], management of subacute and delayed injuries, including PAs and AVFs, is insufficiently addressed in the current literature.

Pseudoaneurysms

Frequently missed during initial imaging studies, pseudoaneurysms (PAs) account for up to 25% of traumatic arterial injuries [1]. Although they may be clinically occult initially due to size, location and extent of the vascular injury, PAs can grow and result in delayed complications including hemorrhage, vessel occlusion, thromboembolic events or mass effect [1,5]. Therefore, appropriate initial and follow-up imaging evaluation can be crucial. As CTA, the main imaging tool for trauma patients, alone has been shown to be only 51% sensitive in detecting vessel injury [11], a low threshold to proceed to DSA should be maintained in all questionable cases.

In our patient, the initial stage of the carotid injury was not identifiable on CTA. Subtle arterial wall irregularities, tortuous segments or bullet trajectories adjacent to an artery or poor CTA quality should prompt DSA. Although invasive, conventional angiography is the superior vascular imaging tool because of its higher spatial resolution combined with selective arterial injections and the lack of bullet artifacts. In addition, it provides endovascular access in cases where immediate repair is necessary. Damaged arteries may appear angiographically occluded in an initial study, when rupture or dissection is followed by clot formation. As demonstrated with the enlarging STA-PAs, follow-up angiograms may improve detection of such occult lesions and any abrupt angiographic blockage should raise the suspicion of underlying arterial wall damage. Optimal therapeutic management for PAs remains controversial and the role of conservative versus surgical or endovascular management has yet to be determined [6]. Surgical treatment is contingent on the location and severity of the injury and may include ligation, clipping, resection with primary anastomosis, resection with interpositional graft, extracranial to intracranial bypass, or patch angioplasty [12]. Although clinical outcomes of these procedures have improved through the years, surgical management, particularly for carotid injuries, is not without risk and can be associated with mortality rates of up to 22% and risk of progression of neurologic deficits up to 21% [13].

Better clinical outcome, shorter hospital stays and improved survival seem to favor en-

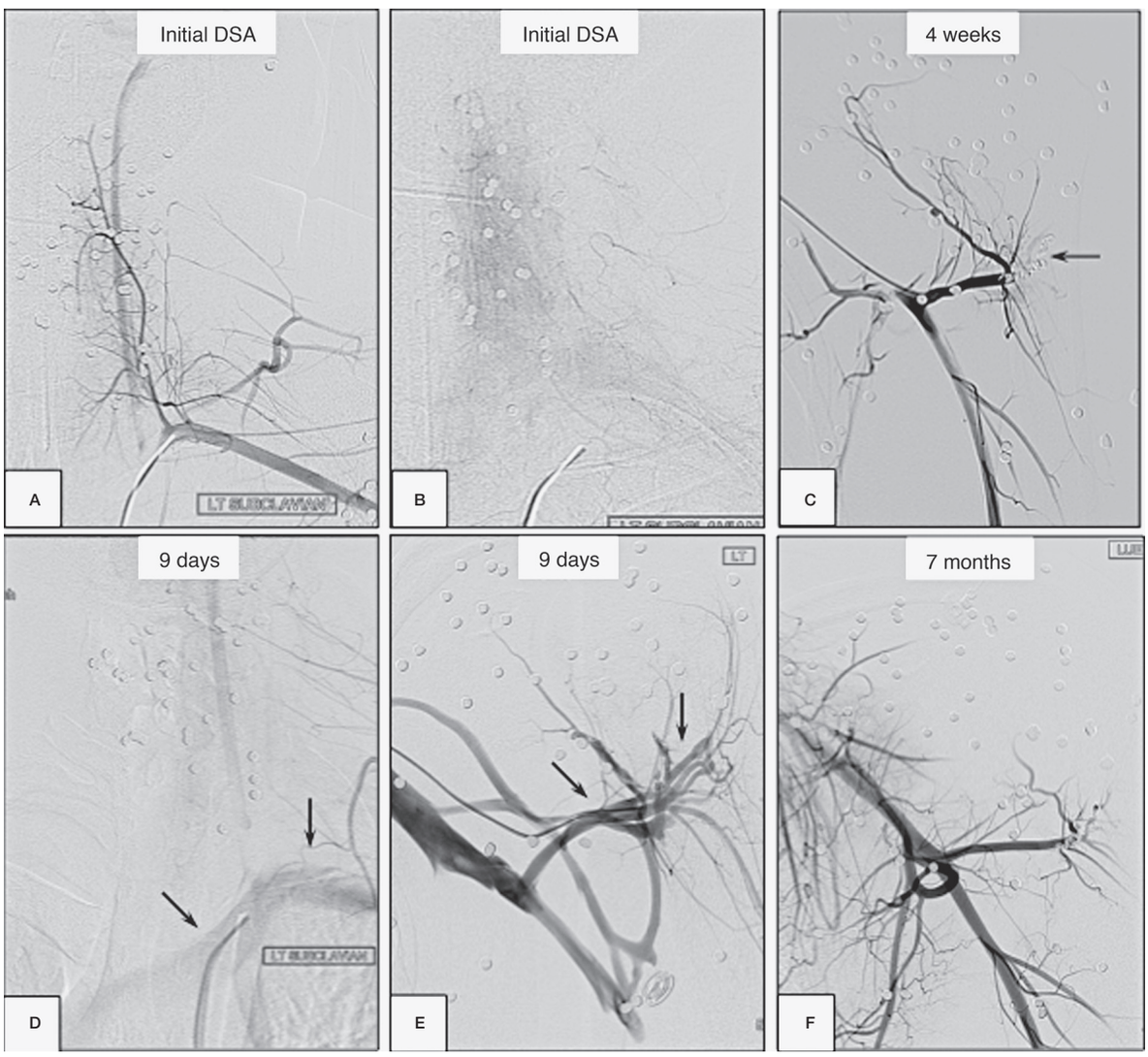

Figure 4 Developing arteriovenous fistula. A,B) Initial subclavian artery injections early and late phase. Note that there is no evidence of arteriovenous shunting. C,D) Follow-up study after 9 days clearly shows early venous drainage caused by a newly developed AV fistula of the left humeral circumflex artery (arrows). E,F) Axillary artery injections; 4 weeks later, transarterial embolization of the arteriovenous shunt using metallic coils (arrow) results in complete occlusion which is confirmed as permanent after 7 months.

dovascular techniques. In particular, the use of covered stents for traumatic ICA injuries has been touted to be safe and effective [14]. EVT may also employ porous stents combined with coils, liquid embolic agents, or other occlusive devices depending on the size and location of the injury.

Although EVT for PA repair is less invasive and can be technically straightforward, these procedures may pose challenges and risks unique to EVT, including embolic stroke, subacute thrombosis, or parent vessel occlusion, which occur at a rate of 8.3% [15]. Additionally, solid organ or other significant tissue injuries may preclude the use of antiplatelet therapy usually required for stent placement. Furthermore, in the US, the use of clopidogrel may present a substantial financial burden, while follow-up and medication compliance in the trauma patient population are traditionally low due to socioeconomic factors. Finally, endovascular occlusion of PA may not always relieve symptoms caused by mass effect, particularly after endosaccular filling with coils or liquids.

While much of the current literature advocates immediate intervention for any traumatic

PA, in the authors' experience, there is also an important role for a nuanced approach, especially for small, non-flow limiting or stable lesions. As seen in the evolution of the carotid and vertebral artery lesions, even initially growing PAs may ultimately regress and heal with conservative management.

In our experience, based on a significant referral rate of patients with acute vascular trauma, in addition to morphology, size and location, impact on blood flow and angiographic evolution, should be considered key factors in the management decision-making. This aspect is becoming more relevant as smaller, non-flow limiting PAs are increasingly being detected with greater frequency due to advances in imaging technology.

However, conservative management may not always be appropriate; it is generally accepted that enlarging or symptomatic PAs should be treated promptly due to a higher risk of rupture. Caution should also be used in patients who may be "lost to follow-up" or have poor compliance. Short-, mid- and long-term follow-up is needed to assess progression or regression and monitor medication compliance. In our case, the last DSA was performed after seven months because the patient was temporarily lost to follow-up, a problem often encountered in patients presenting with GSIs. If feasible we usually perform at least a seven to ten day, four week and three month follow-up study to document any trend of lesion evolution or regression.

Additionally, while a conservative approach is applicable to vascular injuries caused by blunt trauma, it may not be suitable for PAs associated with systemic vascular diseases, such as Takayasu's disease, polyarteritis nodosa, Kawasaki disease, Behcet's, mycotic infection, cystic media necrosis and radiation injury. Whereas traumatic PAs are due to damage of the tunica media, as in blunt trauma, or the entire wall, as in penetrating trauma, vasculitic PAs are caused by lymphocytic infiltration of the vasa vasorum likely resulting in a different natural history.

Arteriovenous Fistula

Traumatic AVFs can often result from penetrating injury and may lead to venous hypertension, ulceration, ischemia and high-output cardiac failure. As demonstrated here, formation of an arteriovenous shunt caused by penetrating injury can also be delayed, highlighting the value of close interval follow-up DSA or CTA after initial studies are negative.

Depending on location and accessibility, treatment of AVFs includes surgical excision and ligation or EVT, if warranted by clinical symptoms. While surgery is most efficacious for large AVFs, smaller AVFs that do not close spontaneously can be managed effectively using endovascular techniques with coils, covered stents or liquid agents. Safe and effective embolization requires occlusion at the fistula site to prevent recruitment of collaterals and recanalization. Complications include non-target occlusion and pulmonary embolism.

Conclusion

Time of occurrence, evolution and regression of penetrating vascular injuries can differ significantly even in the same patient. While symptomatic, enlarging or flow-limiting extracranial PAs necessitate prompt surgical or endovascular intervention, small, non-flow-limiting and asymptomatic PAs may heal spontaneously and conservative medical management with imaging follow-up is a viable therapeutic alternative. Decision-making in the management of gunshot-related PAs and AVFs in the head and neck area should consider symptoms, size of lesion, and impact on blood flow as well as lesion evolution. The possibility of their delayed occurrence warrants follow-up imaging after initial negative DSA or CTA.

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